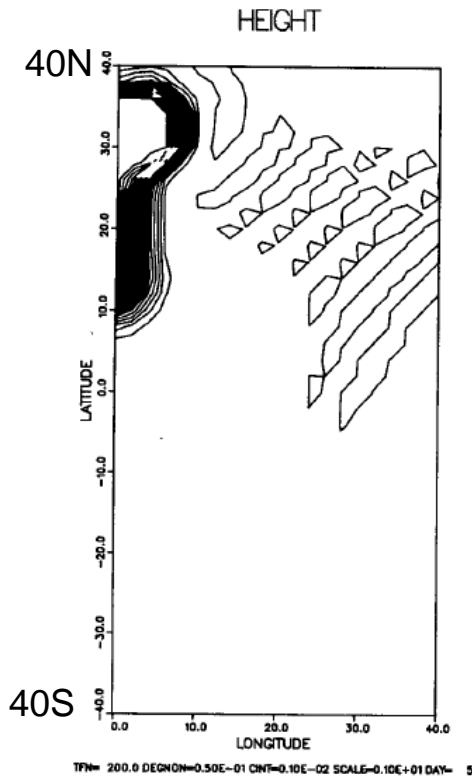
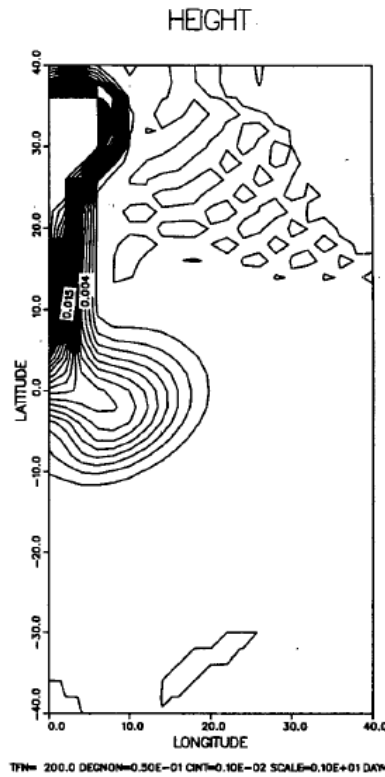


Adjustment to Initiation of an Overturning Circulation

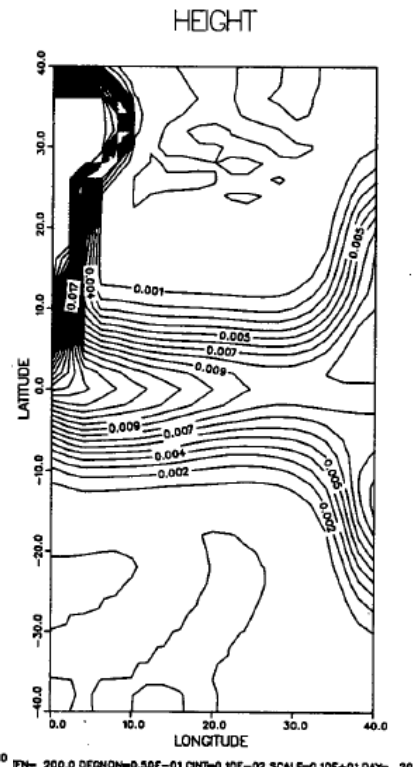
1.5 layer model: Kelvin waves make fast propagation around boundaries
Rossby waves produce slower adjustment



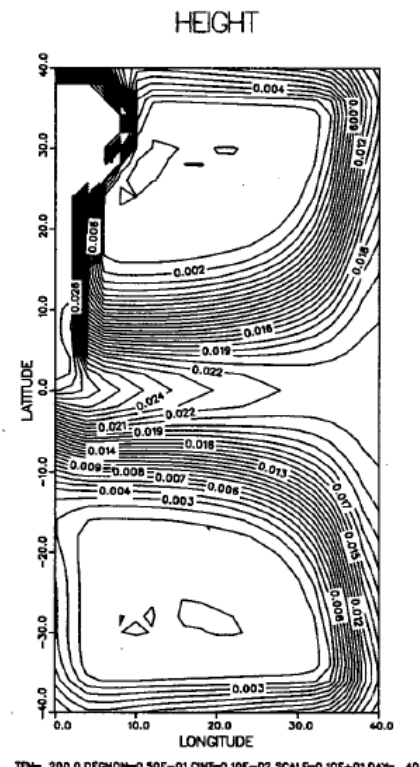
5 days



10 days



20 days



40 days

Kawase (1987, JPO)

Other mechanisms important for adjustment:

- **Advection**

- **Example: SST anomaly carried by current**
- **produces feedback with atmosphere**
- **changes E-P, wind forcing, etc on ocean**

- **Advective-diffusive changes**

Thermocline can change quickly →

$K T_{zz}$ changes →

System adjusts to new state on timescale based on

Balance between diffusion and evolution:

$T_t = K T_{zz} \rightarrow \text{timescale} = D^2/K$

Internally Generated Overturning Variability in Coupled Model

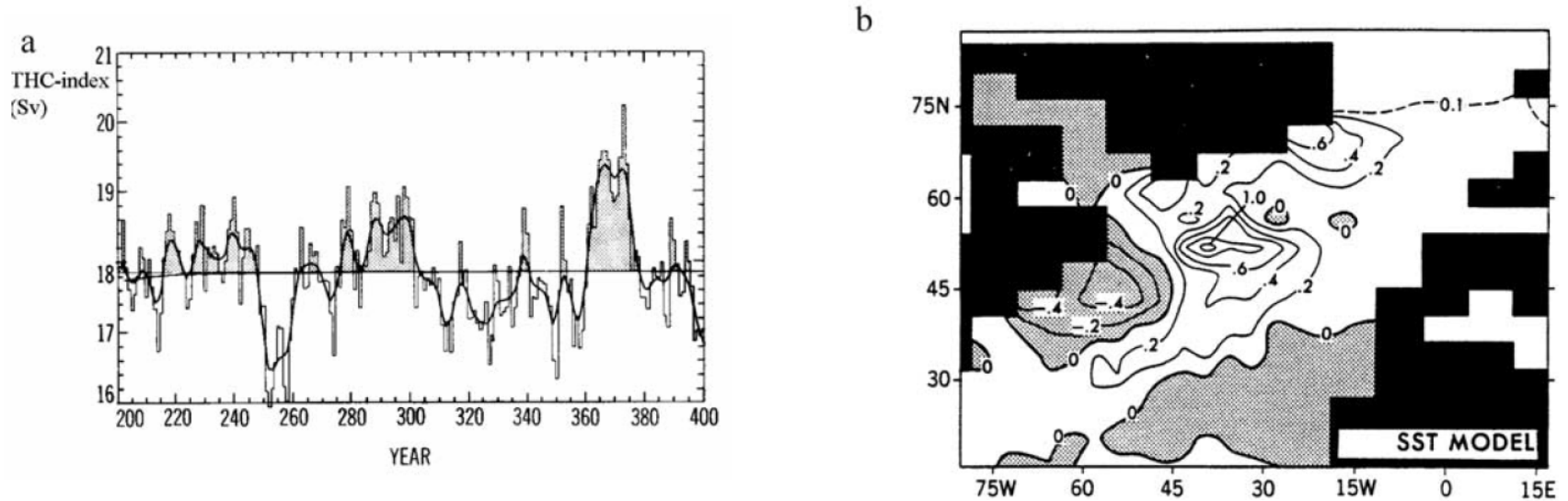
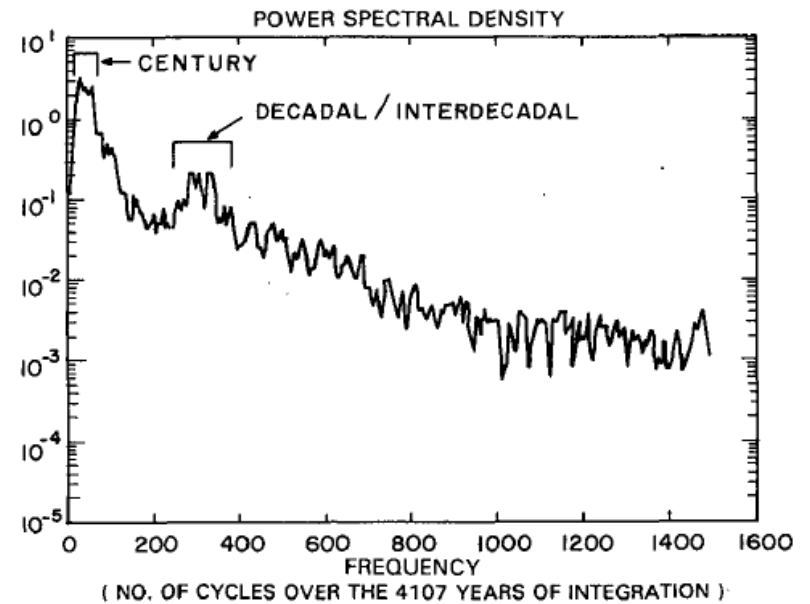
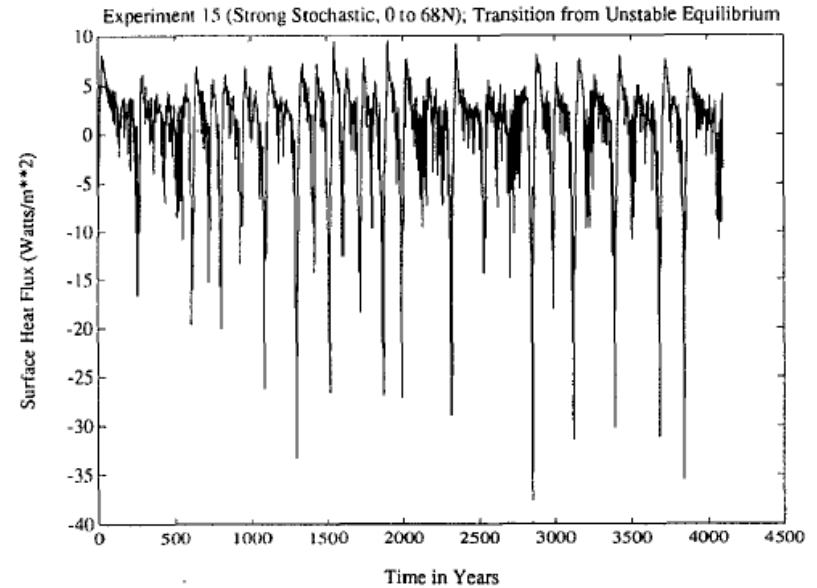
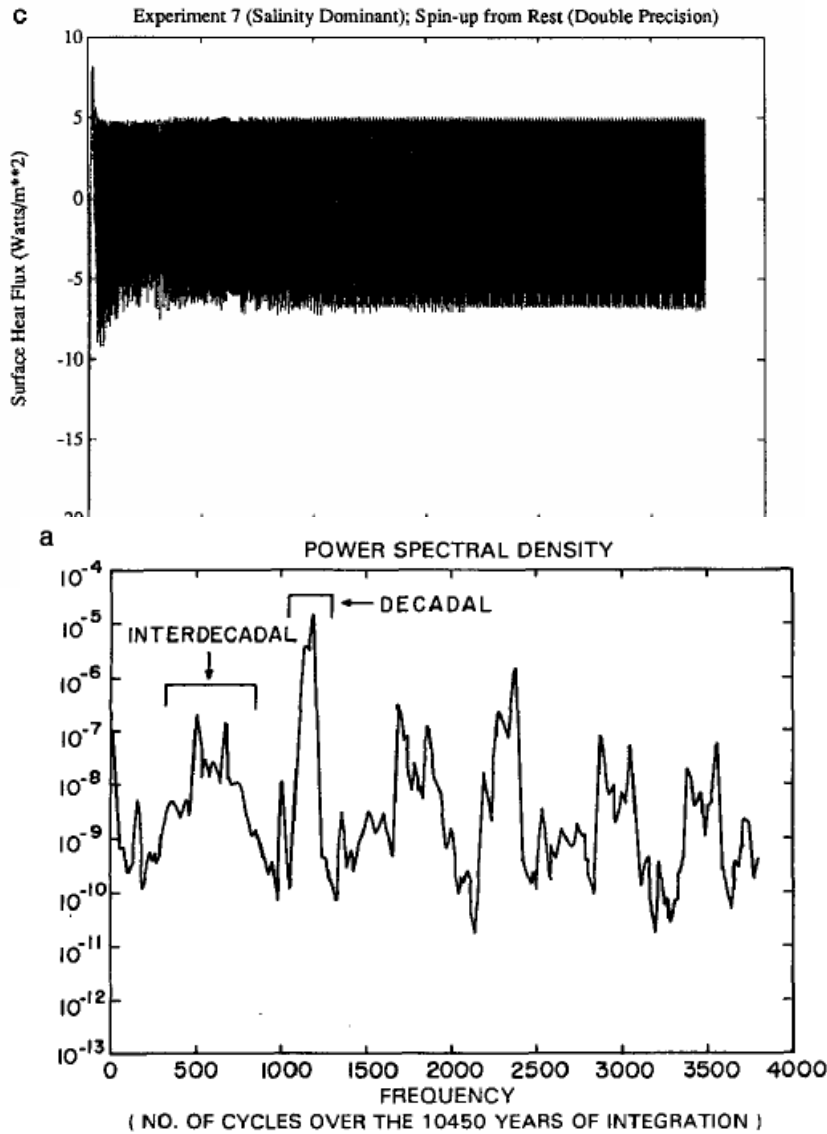


Figure 16. Interdecadal variability in the Geophysical Fluid Dynamics Laboratory coupled ocean-atmosphere model. From *Delworth et al.* [1993]. (a) Time series of annual mean THC index over 200 years of integration. (b) SST pattern obtained as the difference of four model-simulated decades of high-THC-index states and four model simulated low-THC-index states. (c) Pattern of

From **Dijkstra and Ghil (2005, *Rev. Geophys.*)**

Mixed BC's, Idealized Single Basin, Variability Diagnosed from Surf Heat Flux



Weaver et al. (1993, JPO)

Propagation of Temperature Anomalies to Tropics

-0.3 C anomaly isotherm

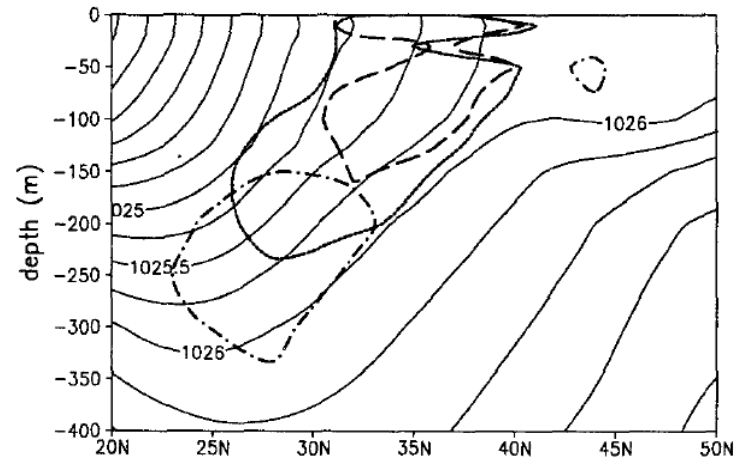
from observations:

Dashed: 1977-1981

Solid: 1982-1986

Dash-Dot: 1987-1991

Deser Alexander and Timlin
(1996, *J. Clim*)



Subtropical-Equatorial Delayed Oscillator

Warm equator in early '90s due to propagation from higher lats?

Oscillation possible due to air-sea feedback:

Strong subtrop wind → bigger evaporation → cooler subtrop ocean

Cool anomaly propagates to equator in ~1 decade

→ cools eq atmos → reduces meridional temperature gradient

→ weaker winds → subtrop warming

Gu and Philander
(1997, *Science*)

Eq. SST, Box Model w/ Feedback and Stochastic Forcing

